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Automatic Steering Control System with Manned and Unmanned Mode for Automated Driving Electric Vehicle

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Abstract- *In this paper, an automatic steering control system for electric vehicles with manned and unmanned mode is proposed. The EPS or MDPS of the automatic steering system used in the conventional engine typed vehicle occurs the problem of handle lock phenomenon while driving of overloading, so that it has limitations to apply to a manned and unmanned electric vehicle. By using electronic clutch and pulleys, the proposed automatic steering system designed steering mechanism that is possible to switch manual and automatic mode. In order to experiment the performance of the steering device, we made an experimental electric vehicle and tested the steering performance through experiments. We confirmed that the proposed automatic steering system was useful for manned and unmanned electric vehicles.*

Keywords - Automatic steering system; unmanned vehicle; electric vehicle; automatic and manual mode

I. INTRODUCTION

Lately, evolved the car's unmanned driving technology and battery technology, interest of developing manned and unmanned electric vehicle is increasing. Apart from technological advances, being serious oil prices rising, energy depletion and air pollution, research and development for manned and unmanned electric cars is rapidly progressing in related industries. Also, auto parts suppliers is developing parts used in unmanned electric cars because manned and unmanned electric cars use different parts and Mechanism that use existing engine.

If people ride manned and unmanned electric vehicle, directly manipulating the handle to move to wherever you want. If people do not ride the car, itself is moving to destination. Manned and unmanned electric vehicle need manual steering device when driving manned and manned, unmanned electric vehicle need automatic steering device when driving unattended. Namely, steering device that is capable of conversion is required.

Mechanical steering device and hydraulic power steering device in a engine vehicle has been used a lot. Recently in case of car that is available for auto parking, electric power steering device EPS, MDPS using electric motors has applied on behalf of the hydraulic device.

EPS is in charge of sponsored role when driving a manned. However, EPS has problems of handle locking caused by overheating to protect the system itself due to self-protection system. Handle locking while driving car causes very dangerous situation.

Most of the vehicle uses engine power and hydraulic power to manipulate the handle. But manned and unmanned electric vehicle needs change of the steering mechanism because it is using battery and motor to move.

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In this paper, we propose design of manual and automatic steering mechanism and controller that have solved problem when applied to electric vehicles.

Proposed steering mechanism is manual and automatic combined steering device of new structure applying pulleys and electronic clutch. Pulley is equipped with steering axis and steering motor axis and activate steering axis by the steering motor after connecting with belt.
We made experimental electric vehicle by applying the proposed automatic steering mechanism. Experimental electric vehicle experiment actual auto mode performance by applying MGS(Magnetic Guidance System).

In section 2, the structure of proposed manual and automatic steering device is described. In section 3, the design of proposed manual/automatic steering mechanism and controller is described. In section 4, performance and usability of steering device proves through experiment with developed manual and automatic steering device.

II. PROPOSED MANUAL AND AUTOMATIC STEERING DEVICE

In this paper, configuration of manual and automatic steering device using proposed electric clutch is displayed to Figure 1.

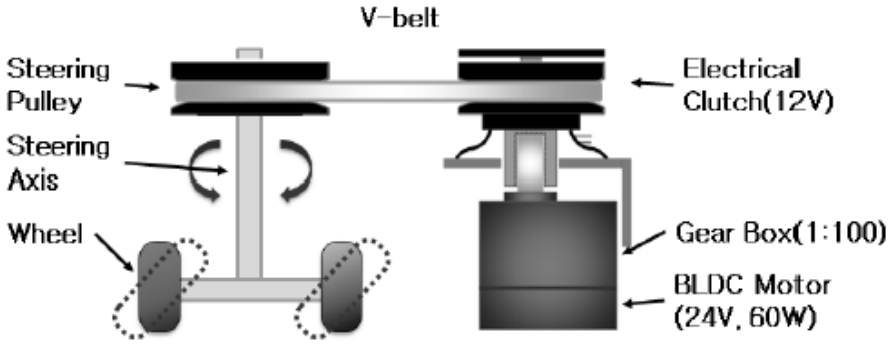

Figure 1.Structure of proposed automatic steering mechanism.

Connect electric clutch to BLDC motor and electric clutch and steering axis are connected through pulleys and belts. If voltage is applied to the BLDC motor and the control signal is passed to BLDC motor, power is delivered to steering axis by belts. By applying electric clutch in steering mechanism, manual and automatic mode can be freely converted. Electric clutch can easily convert between automatic steering mode and manual steering mode by power control. Steering control of the vehicle is possible by BLCD motor when auto mode and it is possible by using handle when manual mode. To get appropriate performance, proposed steering device needs the design of the mechanism that meets the specifications for vehicles and the design of the controller that consider electric clutch and pulley.

III. DESIGN OF AUTOMATIC STEERING SYSTEM USING ELECTRIC CLUTCH

A. Design of Automatic Steering Mechanism

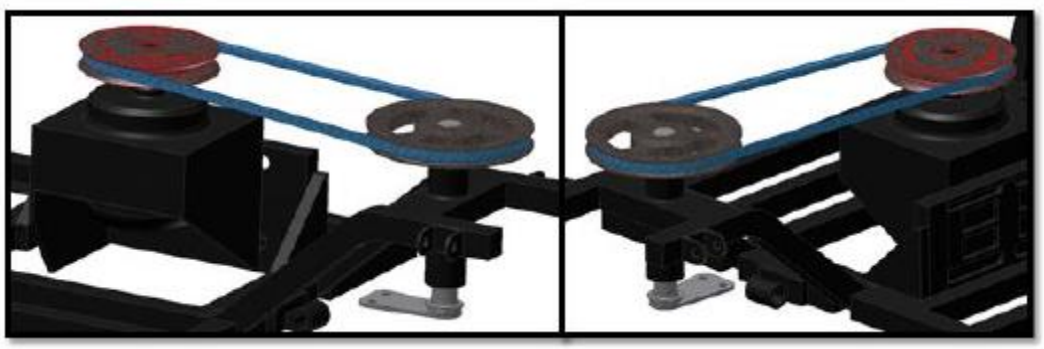

Figure 2.3D CAD drawing of steering mechanism using electrical clutch and pulley.

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As shown in Figure 2, vehicle steering mechanism can be designed by using 3D CAD analysis that specification is suitable. Electric clutch, BLDC motors, pulley, belt, steering shaft was measured, and steering mechanism was designed using simulation.
B.Design of Automatic Steering Controller

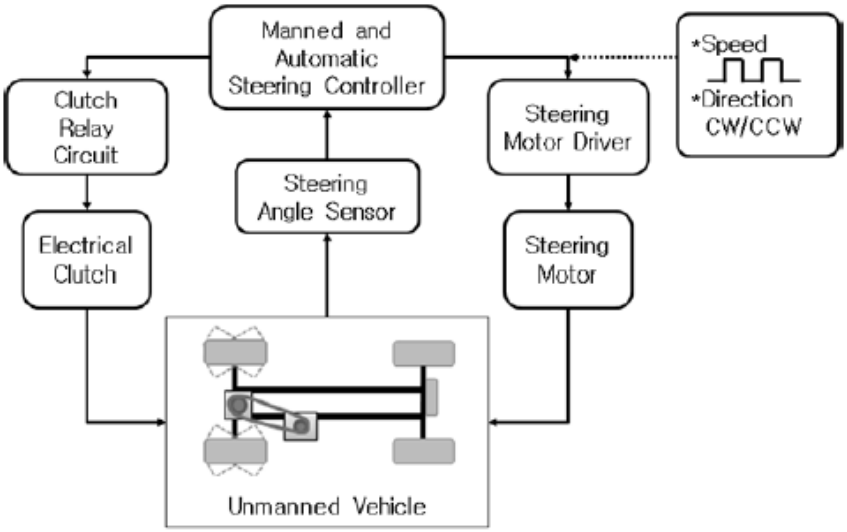

Figure 3. Block diagram of control system of manual and automatic steering system.

Steering control block diagram for proposed automatic steering mechanism is shown in Figure 3. Manual mode or automatic mode is selected in manual and automatic steering controller, and then electric clutch is operated by clutch relay circuit. After automatic mode was set, steering controller transmits PWM and direction signal to BLDC motor driver. The torque of the steering motor transfers to the electronic clutch through the pulley and the steering angle of front wheel is change, and steering angle sensor measure steering angle. Manual steering using handle, as opposed to the automatic mode, electric clutch and BLDC motor power is off.

IV. THE EXPERIMENT OF AUTOMATIC STEERING DEVICE

A. Manufacture of Experimental Electric Vehicle

To test proposed manual and automatic steering device, we design and manufacture experimental manned/unmanned electric vehicle such as Figure 4. The body length of the platform is length 1410mm × 630mm × height 600mm width, it can sustain up to 150kg and it was designed to meet 1,5m turning radius. We constitute steering system by using 24V BLDC motor, electric clutch, pulley and belts. For Automatic steering tracking experiment, the front of the car is equipped with MPS(Magnetic Position Sensor).

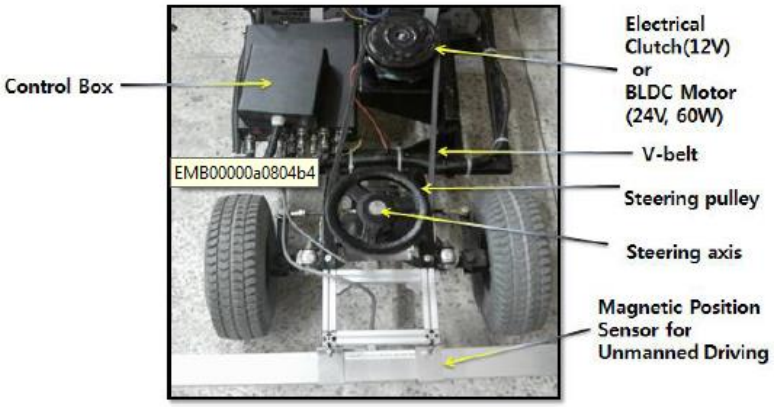

Figure 4.Developed Manned and Unmanned Experimental Electrical Vehicle.

B. Experimental Condition of Motor Characteristic

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We were tested manual and automatic steering system of developed manned and unmanned electric vehicle. We analysis date after we implement behavior experiment of steering angle according to input voltage value of auto steering device. To obtain characteristic curve of automatic steering system, we increased input voltage value and driven motor and calculated steering angular velocity of rotation of electric cars depending on automatic steering system operating when we measured moving time -30 degree to 0 degree of Electric vehicle steering angle.

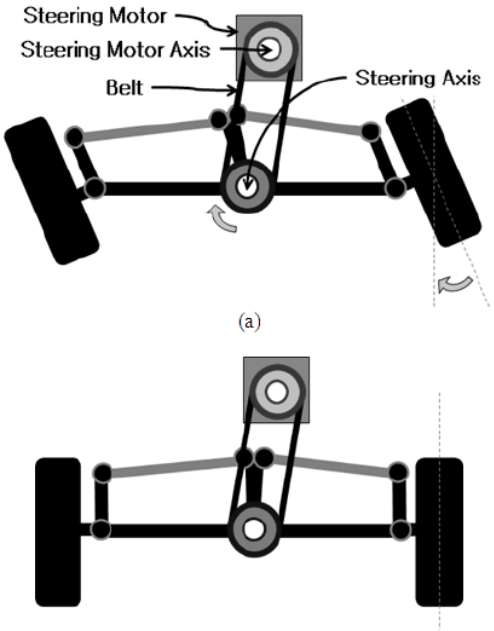

Figure 5. Experimental condition ; (a) Initial steering angle position (b) Target steering angle position.

Formula for evaluating the steering angle velocity is as follows:

$$\omega = 30° \times \pi/180°/ST$$

Ω is the speed of the steering angle, ST is the time it takes to reach this target steering angle(Steering Time).

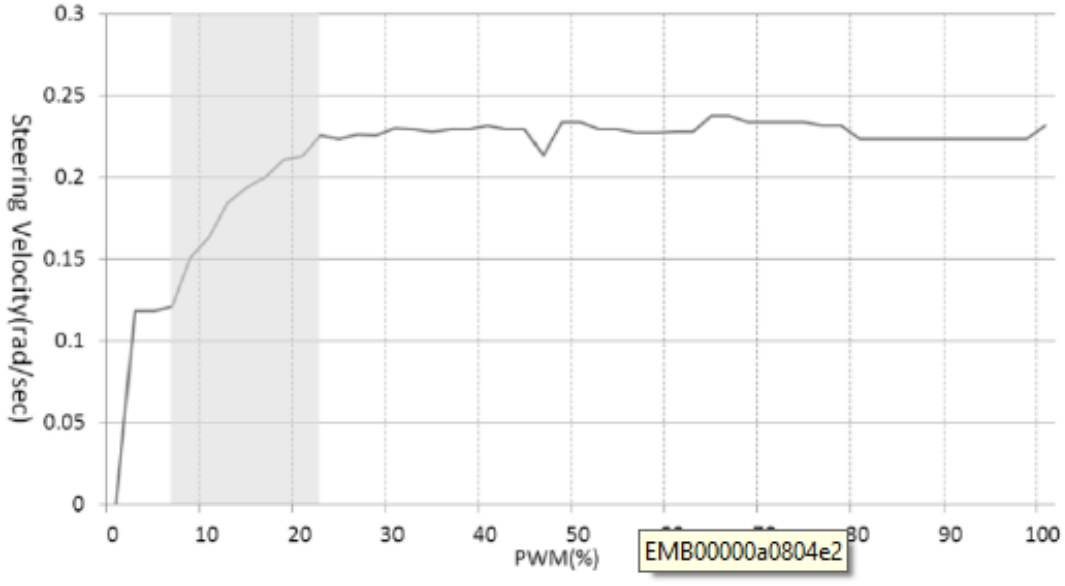

Figure 6.Experimental result of characteristic of steering system.

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Figure 6 indicates result of automatic steering device characteristic. PWM indicates the size of inputted voltage to steering motor. Steering velocity indicate rotating angular velocity of steering axis in steering mechanism of electric vehicles. In characteristic experiment result, we know that steering angular velocity is nonlinear by input voltage PWM.

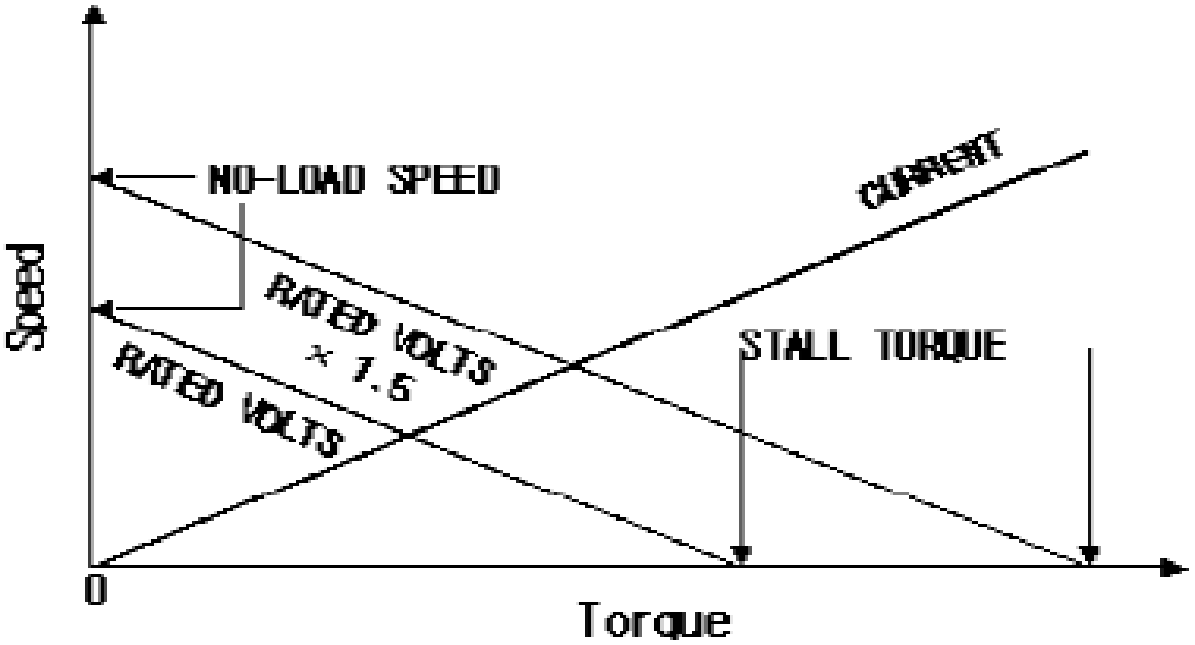

Figure 7.Characteristic of BLDC motor.

Generally, BLDC motor's characteristic is to show linear attribute such as Figure 7. Shown as Figure 6, automatic steering system of electric vehicle using BLDC motor is to show non-linear characteristic for input voltage to angular velocity. That is expected nonlinear characteristics due to mechanical characteristic of electric clutch and pulley of steering mechanism. The power of BLDC motor is transmitted from electric clutch, belt to steering axis. Electric clutch is power transmission part by friction of disk. Depending on the characteristic of the disk may occur transmitted power loss. In addition, transmitted power loss can occur by belt tension between BLDC motor pulley and steering axis pulley. Therefore, it is required to compensate controller design.

C. Experimental Result of Auto Steering Controller

Considering non-linear character of steering motor, design a auto steering controller. Figure 8 indicates compensator and control block diagram compounded p-d controller.

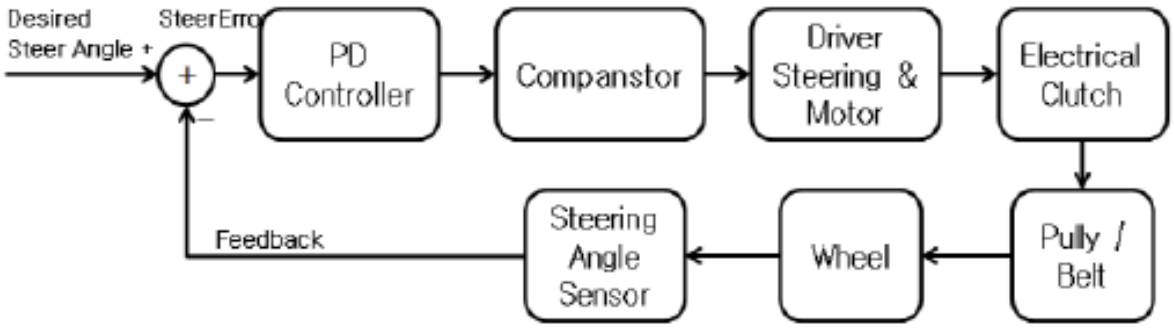

Figure 8. Control block diagram of automatic steering system.

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Looking at the control process, steering motor is operated by enter a desired steering angle to controller and compensator. Steering motors power rotate steering angle of front wheel through electric clutch, pulley and belt. Estimated current steering angle at steering angle sensor of steering axis is reflected precise steering control.

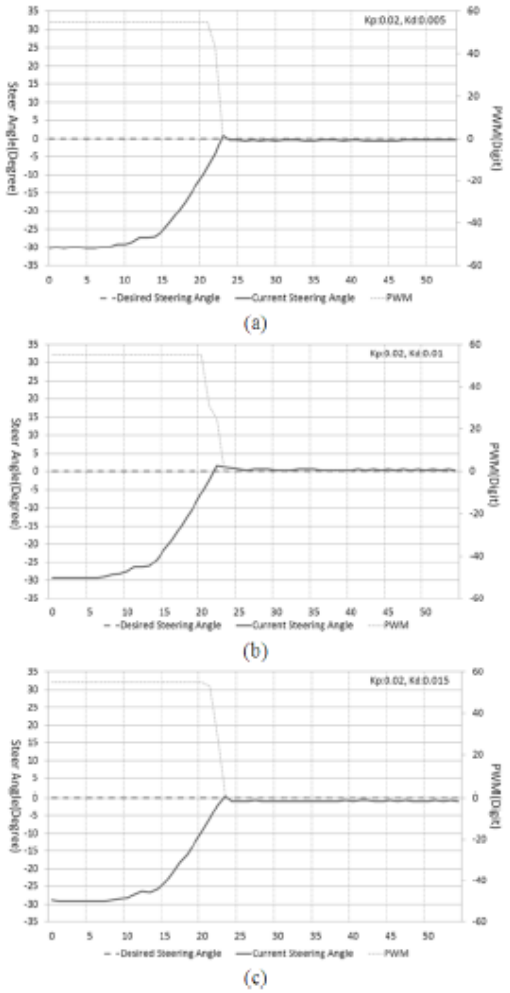

Figure 9. Experimental result of automatic steering according to PD parameters ; (a) Kd:0.005 (b) Kd:0.01 (c) Kd:0.015.

Figure 9 indicates steering experiment result of automatic steering control. Value of Kp is 0.02, changing value of Kd to 0.005, 0.01, 0.015, we tested steering angle control. The first steering angle was -30, when hopeful steering angle was inputted to 0, I measured change of steering angle up to 0. As examine the result of the (a), (b), and (c) experiment, you can confirm that control is accomplished.

D. Experimental Result of Manual and Automatic Steering Control

Action experiment of electric vehicle installed developed automatic steering device was operated. The manual steering test of manual and automatic steering device invented with a wireless remote control was carried out. According to input of MPS, experiment of automatic steering was carried out. after unmanned driving test along the magnetic pat was carried out , I analyzed data of steering angle and confirmed action of manual/automatic steering device.

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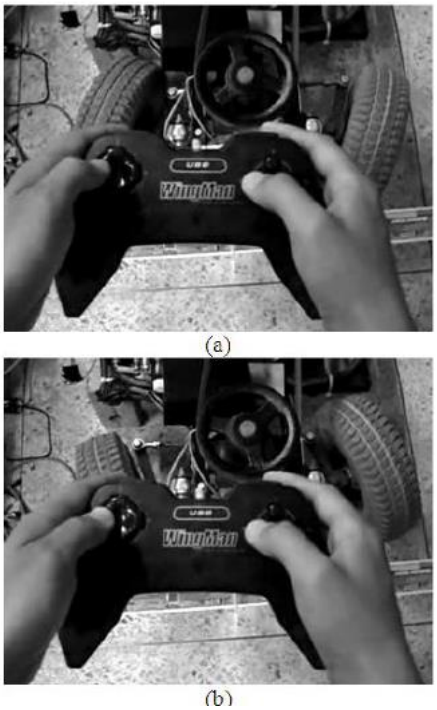

Figure 10. Manual Steering Test Using Remote Controller: (a) Right Turning (b) Left Turning.

Figure 10 is manual steering experiment used in remote control.

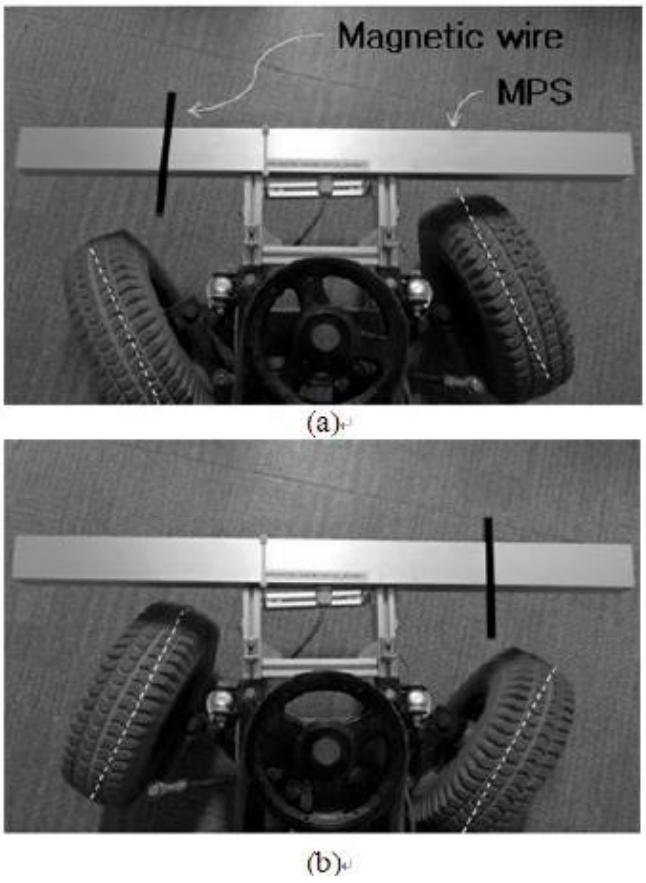

Figure 11. Automated steering test using MGS : (a) Left turning using MGS (b) Right turning using MGS.

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Figure 11 is automatic steering experiment of electric vehicle used in MPS. That steering of electric vehicle is accomplished according as input of MPS was confirmed.

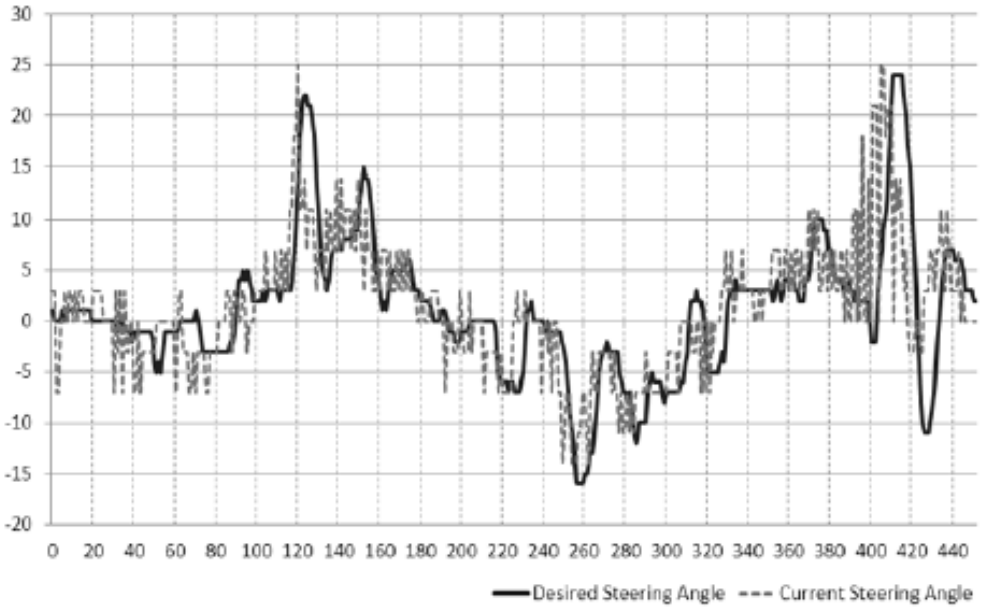

Figure 12. Result of automatic steering test.

Figure 12 is picture of automatic steering experiment used in MGS in automatic steering electric vehicle. Magnetic path measured by MGS, converted to desire steering angle is conveyed to auto steering controller. The steering of vehicle is accomplished by auto steering controller, and current steering angle was measured through steering angle sensor. According to result of the experiment, accomplishing steering of electric vehicle was confirmed by application of automatic steering device used in electric clutch and pulley.

V. CONCLUSION

In this paper, the device that is possible manual and automatic steering used in electric clutch and pulley was suggested. for a test of performance of designed manual and automatic steering device, experimental magnetic guidance electric vehicle was produced. In background of the experiment of quality and interpretation of automatic steering device, after installation of controller, manual and automatic steering experiment was operated. Also, according as MGS driving test that manual and automatic steering device developed through experiment is useful was confirmed.

Acknowledgment

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